E. M. Baker

The Monthly Review

AMERICAN ELECTROPLATER'S SOCIETY

A SOCIETY FOR THE
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ELECTROPLATING

SEPTEMBER — 1942

AMERICAN ELECTROPLATERS' SOCIETY

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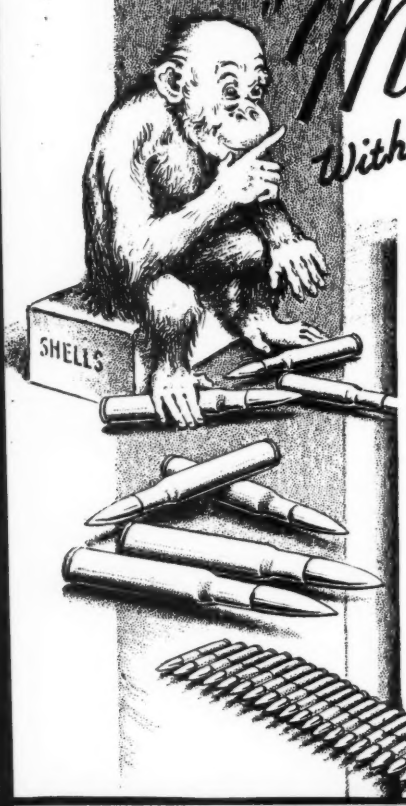

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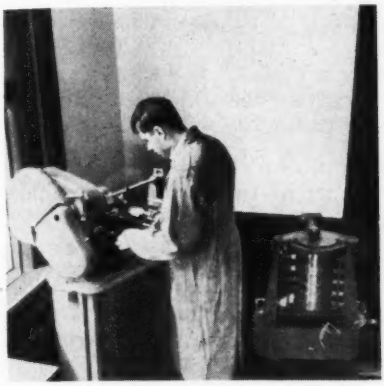

THE COVER

Corner of Development Laboratories of Lea Manufacturing Co. Waterbury, Conn.

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Electroplaters in the War

Recently a member of the Armed Forces of the United States made the statement that the United States is losing the war very rapidly and never in the history of this country were conditions so unfavorable as they are today. We have heard mention that the conditions today are about the same as in the first year of the Civil War or the first two years of the Revolutionary War but military analysts do not agree with this theory.

The fact is that we are in a war where men are no longer the prime consideration. Today, metals in the form of armament are the most important thing and it is essential that we produce and deliver them to the proper places with the utmost speed.

With metals being so important the members of the A.E.S. can serve a most useful function. The Electroplater is called on to apply the war time finishes rather than the decorative finish which he has been more familiar with and he is also called on to do certain cleaning and burring operations between the various steps of a finished unit. These are the natural functions of a Finishing Department and it is proper that we take over these operations.

There is a more important function which he can fulfill and that is in the conservation of metal. There is no other method which is commercially used today whereby practically any metal can be applied to another one for a specific engineering purpose. By proper Electroplating it is possible to use non-critical base metal and electrodeposit a critical metal on to it and thereby save critical metal in the final unit. The Plater can further save metal by plating just the proper amount on the part as uniformly and continuously as possible so that there is no excess metal wasted from non-uniform thickness and no excess metal plated to overcome porous or other defective plating. In addition to this there is the general saving around the Plating Room by taking care of drag-out metal deposited on racks and other wasteful practices.

It is the duty of every member to not only effect this economy but to pass on the information so others may do likewise. It is the function of the branch meetings, regional meetings and the MONTHLY REVIEW to disseminate this information and we expect the members to make use of these facilities.

Our opportunity for helping out the war effort is an excellent one so let us do our part. The editor will set up a department for the purpose so send in your shop hints.

Electro-Tinning

By S. BAIER

International Tin Research Council, Fraser Road, Greeford, Middlesex England

As tin retains its white lustrous appearance even after prolonged exposure to the atmosphere and resists attack by the common organic acids, it is safe and attractive to use in contact with foodstuffs and for many other purposes. But because of its cost and relative softness tin is most commonly used as a thin coating on cheaper and harder metals. Kitchen utensils and the ubiquitous tin can are the most familiar examples.

Tin coatings have in the past been obtained almost exclusively by immersing the base metal in a molten tin bath. During the past decade, however, the process of electrodeposition has been increasingly adopted. This process makes possible a thin and uniform coating even on articles of irregular and uneven surface.

The normal tin-plating solutions give matt deposits, but there are many instances where such coatings being required for protective purposes can be used without further finishing, as, for instance, parts of refrigerators, and for the interior surface of food-processing equipment. Where a brighter surface is wanted wet scratch brushing is particularly popular, and is used on shelves and fittings inside kitchen cabinets, ice boxes, refrigerators, etc.

For certain types of work the following features of this process have been specially appreciated:—

(1) Plating is a reliable means of applying a coating of definite and uniform thickness within accurate limits. As an example, a thin coating of tin is applied to automobile pistons, piston rings, etc., to reduce friction and abrasion and the liability to seizure arising in the running-in period. Such tinned parts are used without subsequent machining.

(2) Coatings up to 0.020 in. can easily be built up, whereas it is difficult by hot dipping to get a thickness greater than 0.001 in. For special purposes coatings up to 0.125 in. have been produced without difficulty.

Plating provides a protective coating which is assured

of a long life and has been used to make surfaces which form a joint without a gasket.

(3) Tin-plating baths, and especially sodium stannate solutions, have remarkably good throwing power and provide an excellent means of applying a uniform protective coating to complicated components after fabrication. For example, valves on milk vessels and cooling units of refrigerators can be plated in one process, whereas any other finish would entail the separate treatment of a number of individual components prior to assembly.

(4) Thin coatings can be applied which although possessed of quite limited protective properties provide an exceedingly economical protection for delicate metallic parts during periods of storage.

(5) The use of thin electro-depositsed tin coating on parts to be subsequently soldered has been found a satisfactory method of reducing soldering costs and avoiding the difficulties arising from the use of corrosive fluxes.

Economies, no less than the high degree of protection obtained, have drawn attention to the possibilities of still wider application of the electrodeposition of tin, and the art has so far advanced that it may be claimed that:

(1) Plating solutions may be quickly prepared from standard chemicals on the market;
(2) Anodes are easily obtained;
(3) Equipment is readily available;
(4) The process can be operated satisfactorily under ordinary factory conditions;
(5) Control of deposits and of the bath is simple;
(6) Anode and cathode efficiency can be closely balanced;
(7) The baths have good throwing power and hence coatings are of uniform thickness;
(8) Deposits adhere well;
(9) A wide range of closely controlled thicknesses of deposit is possible;
(10) The deposits have excellent protective qualities.

Types of Baths in Use

(1) *The Stannate bath* (usually sodium stannate) is now the most widely used type owing to its simplicity and reliability, and is employed on both small scale and fully

automatic plants in America and in Europe. It is the most useful of the "alkaline" baths and combines excellent throwing power with a smooth compact deposit throughout a range of conditions that are easily controlled and maintained in practice. The continuous replenishing of the bath with the tin ion from pure tin anodes presents no difficulty.

(2) *The acid bath* (usually stannous sulphate) was originally developed for a tin-refining process, but the development of addition agents has made it attractive because of the high current efficiency, the low operating temperature, and its general stability to atmospheric influences. The bath appears to offer the best possiblities for the continuous plating of strip, etc., and much development work is going on. It has already come into use on a commercial scale for general plating.

(3) *The Oxalate Bath* is sometimes used for tin plating, especially for purposes where it is undesirable to use the very acid sulphate baths or the very alkaline stannate baths, but it is not suitable for ordinary commercial plating. The solution is almost neutral and is easy to prepare, but can only be used at very low current densities.

(4) *The Stannous Chloride-Caustic Potash Bath* was at one time commonly used, but it has a very narrow range of conditions over which it can give satisfactory deposits. It also suffers from rapid oxidation from the air and soon turns into a sort of stannate bath badly contaminated with stannite and chlorides. This bath is so frequently the source of unsatisfactory coatings that its use is becoming much less common. It cannot be recommended for any purpose.

As with all electro-processes, adequate cleaning and preparation of the base metal is of the first importance. When using the tin baths described below greater care in cleaning is required for the acid baths and in their case it is important that traces of chlorides should not be left on the work.

The value of the coating is considerably affected by the finishing treatment adopted and owing to the softness of the Coating normal polishing methods are not, in general, satisfactory. Wet

scratch-brushing with a soft brass or nickel silver wire brush gives an attractive finish without loss of tin. Among satsifactory additions to the water for scratch-brushing, size, soluble oil, and lanoline emulsions have been used.

Steel tanks with a loose lining of reinforced glass are preferable, wood and most plastics are liable to attack by the alkali present. Heating is best carried out by internal steel steam-heating coils which should be supported some inches above the bottom of the bath to allow the sediment to remain undisturbed.

Electrical equipment is as for other plating processes.

The bath is essentially a solution of sodium stannate containing a little free caustic soda; the presence of sodium stannate is detrimental and must be avoided. The preferred concentration of the various dissolved salts depends on the operating temperature and/or the cathode current densities chosen and reference should be made to Fig. 1, where satisfactory combinations of the major factors are shown diagrammatically, but a normal range of composition is:—

	grm. per litre.	*oz. per gal.*
Sodium stannate, $Na_2SnO_3 3H_2O$	55 to 100	9 to 16
Free caustic soda	10 to 15	$1\frac{1}{2}$ to $2\frac{1}{2}$
Sodium acetate (if desired)	15 to 30	$2\frac{1}{2}$ to 5
An initial addition of hydrogen peroxide (100 vol.) or Sodium perborate	2/5	$\frac{1}{16}$

To make a solution. Fill the plating bath about two-thirds of its depth with water at about 167°F. (75°C.), add the sodium stannate (for purity of this salt see above), and when it is completely dissolved add the caustic soda. Before adding further ingredients, fill up the bath to its working level and check the bath concentration for tin and free caustic soda as described below. When these have been adjusted add the sodium acetate, if desired, and oxidizing agent and the bath is ready for use.

The sodium stannate is a reservoir of tin which is given up to the cathode and constantly replenished from the anode. A weak solution necessitates a low current density and hence slow plating. Caustic soda, in the amounts recommended, is required to maintain the tin in solution without the formation of tin hydroxides, and to ensure the proper dissolution of the anode, see above. Sodium acetate is described as a "buffer salt" and is claimed to widen the range of conditions under which satisfactory deposits are obtained.

Hydrogen peroxide and sodium perborate are oxidizing agents, and are added to new solutions to oxidize any traces of stannite or traces of undesirable impurities which may happen to be present in commercial sodium stannate. The hydrogen peroxide is decomposed completely within a few hours and is not an essential constituent of the bath. If, however, stannate ions should inadvertently form in the bath they must be removed by an addition of hydrogen peroxide. This will oxidize the stannite but will not of course prevent the anodes producing further stannite if they have become defilmed.

Values from 10 to 25 amp. per square foot are in use; 15 amp. per square foot is normal. Higher values must be accompanied by higher bath temperatures, and the caustic content should be adjusted. Little saving in the time for plating any given thickness is achieved by using current densities greater than 25 amp. per square foot, however, as the cathode efficiency falls off, and control becomes more difficult. The relationship between current density, bath concentrations, and temperatures is shown in Fig. 1.

Anodes should be of pure tin and preferably narrow to equalize current density on back and front. They can be of uniform cross section as filmed anodes have no tendency to "waist" at the water line. The operating current density, once the film is established as described below, should be about 1 1/3 that used at the cathodes, i.e. the anode area, calculating only the surfaces facing the cathodes, should be about $\frac{3}{4}$ the cathode area. The anode efficiency under such conditions varies between 75 per cent and 95 per cent according to the current density employed. It is very important that the conditions are such that the tin is dissolved in the quadrivalent, stannate, form. When this is occurring, the anodes are filmed with a greenish-yellowish coating. The appearance is very characteristic and is easily recognized. If the anodes remain a clean grey color, or are coated with a thin loosely adherent film of dark particles, the current density is too low and the anodes will dissolve rapidly as stannous tin, and tough spongy deposits will be produced. Should the current density rise too high, oxygen is given up at the anodes and little or no tin is dissolved, and the anode surface becomes at first brown, and later is covered with a highly insoluble black oxide film which is difficult to remove except with strong mineral

acids. Plating will continue satisfactorily for a time but efficiency will decrease as the solution is depleted of tin.

To obtain the proper film on the anodes the following procedures are used:—

(1) *Where the anodes are lifted out of the solution when the bath is not in use*:

The work is loaded into the vat first and then the anodes are lowered slowly (say 1 inch per second) into the solution with the normal current switched on. Individual flexible connecting leads to each anode greatly facilitate forming and maintaining the film. As the anodes enter the solution, the first portions receive a high current density and immediately film over, and then, as the anodes are progressively immersed, the films spread over their whole surfaces.

(2) *Where the anodes are kept permanently in the solution*:

Anodes should be bolted or clamped to the busbars and not merely hung on hooks.

On commencing to plate, an excessive current density is applied for the first minute or so. This current is 1½ to 2 times that used for the fully loaded vat. The film will form rapidly and its completion will be noted by the experienced eye. As a check it will be noted that the voltage has risen suddenly about 2 volts and the ammeter has fallen correspondingly. Once the film is formed the current may be dropped to the normal operating density.

The behaviour of the tin anodes is easily understood when it is realized that there is a critical range of anode current density below which the tin dissolves as stannate, and above which the anode becomes satisfactorily filmed. The critical density varies directly with the free caustic soda content and with the temperature. Its value also increases slightly with increasing stannate concentration. Continued application of current densities higher than the critical will gradually cause complete passivity of the anodes, but if the current is lowered after the anodes have become filmed, continuous dissolution of tin as stannate is assured.

A six-volt source of current is usually adequate as the voltage drop across the busbars is normally between 3 and 4 volts. The

bath is commonly worked at 75°C. (167°F.) and suitable temperatures in relation to the other conditions are shown in Fig. 1.

Free Caustic Soda

If the free caustic content drops, the bath is liable to precipitate insoluble hydroxide of tin, and as carbon dioxide from the air is absorbed into the bath to form sodium carbonate, it is advisable to check the free caustic content at least twice weekly as described below, as it is best to keep its content within ± 1 grm. per liter of the quantity recommended.

With operation prolonged over several months, excessive quantities of sodium carbonate will accumulate in the bath, and should be removed as it tends to lessen the cathode efficiency. This can be done by allowing the bath to cool. If a tray of iron or nickel gauze is immersed in the bath before and during cooling large crystals of $Na_2CO_3 10H_2O$ form on the tray and can easily be removed.

The most economic concentration for the bath depends on the current density and temperature employed and may be determined from the chart, Fig. 1.

The enclosed areas represent the range of concentrations for satisfactory plating at each particular cathode current density. The solution concentration is given on the vertical scale and the temperature on the horizontal scale.

For example, if it it desired to work at 15 amp. per square foot the chart indicates a solution containing 40 to 45 grm. per liter of tin and 12½ grm. per liter of free caustic soda for working at 75°C. If, however, the temperature is to be raised to 80°C. the tin content should be 30 to 35 grm. per liter and the free caustic 10 grm. per liter.

The efficiencies at each current density are given within the enclosed areas, while the times needed to plate 0.001 in. coating are given alongside.

The figures refer to normal solutions under industrial conditions containing fairly considerable amounts of sodium carbonate (100 grm. per liter). New solutions free from sodium carbonate would give 90 per cent efficiency at each current density. If the plating solutions are weaker than those shown they may give greatly reduced efficiency, but on the other hand more concentrated solutions give only slightly greater efficiency.

By using the conditions recommended in the chart together

THE SODIUM STANNATE BATH

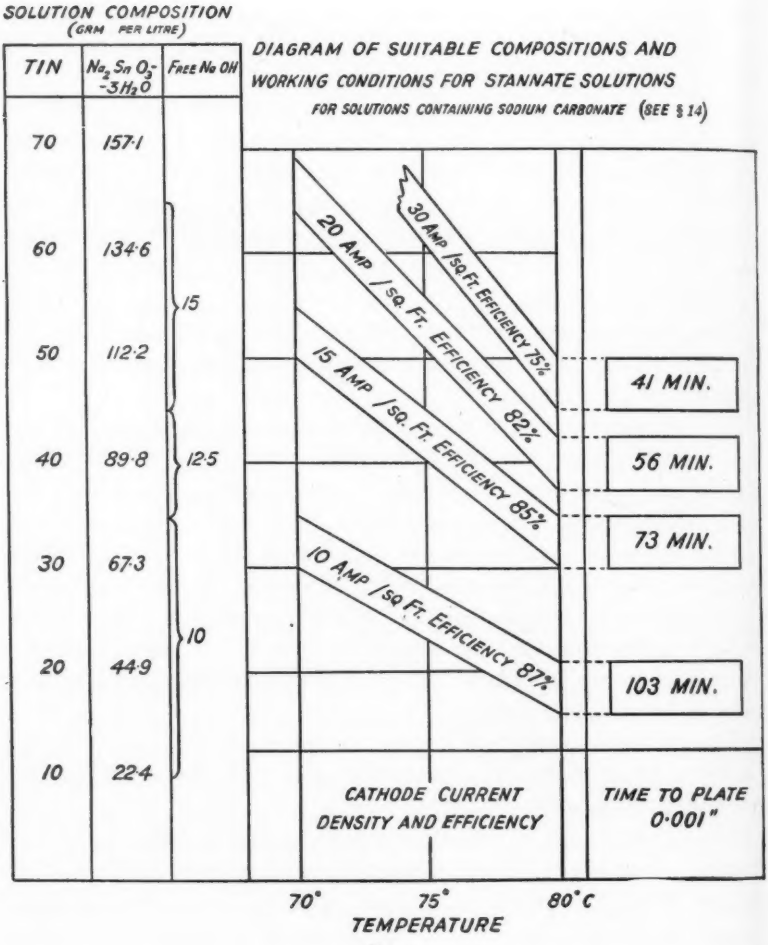

FIG. 1

with the correct area of anodes, the bath should maintain its composition over long periods and require no additions of salts apart from the caustic soda required to make up for losses due to the absorption of carbon dioxide. Maintenance of the correct amount of free caustic soda is important for balancing anode and cathode efficiency; for while alteration of other factors, such as temperature, affects both anode and cathode efficiency in a similar manner, decrease in free caustic soda will raise the cathode efficiency but lower the anode efficiency. In practice the optimum anode area is affected to a certain extent by the amount of tin lost through "drag-out". For this reason periodic check analyses of the tin content should be made: the anode area being increased of the tin content falls and vice versa.

Occasionally practical platers add to the bath organic agents such as lactic acid (6 grm. per liter), tin resinate ($\frac{1}{4}$grm. per liter), or resin ($\frac{1}{4}$grm. per liter), the purpose being to improve the color of the deposit. Such additions must be made with great caution, as they do not disperse readily throughout the bath and may give rise to a patchy appearance on the deposits. There is also a tendency to reduce the cathode efficiency when first added.

Sometimes solutions will not give deposits as white or as smooth as desired. Raising the temperature, or lowering the current density will often improve quality. If not, the trouble may be due to stannite ions and an addition of hydrogen peroxide or sodium perborate is called for.

Deposits of unsatisfactory appearance may also be produced if the bath contains certain metallic impurities, derived, for example, from the use of impure tin anodes or impure sodium stannate. Such impurities usually disappear on working the bath with pure tin anodes.

Since it is absolutely vital that the anodes be kept filmed, and as the film will dissolve off very rapidly if the current is cut off, it is desirable to ensure that the bath works as continuously as possible. It is sometimes convenient to employ "false cathodes", for example, thin sheets of pure tin which may be used to provide a small load when there is no other work in the bath; these can subsequently be used as anodes.

As a precaution against accidental defilming of the anodes, all electrical connections should be as reliable as possible, and anode connections should be by nuts and bolts or other rigid

attachment. Connection by merely hanging on a hook is unsatisfactory, as, if even only one anode becomes defilmed, sufficient stannite will quickly be formed to contaminate the bath.

ANALYTICAL METHODS OF CONTROL

Free Caustic Soda.

Reagents required:—

(1) Standard hydrochloric acid 0.1N;
(2) Barium chloride solution $BaCl_2$ (10 per cent);
(3) Thymolphthalein indicator, 1 per cent in alcohol.

A 5-cc.. sample of the bath is transferred by means of a pipette to a conical flask, add 50 c.c. of the barium chloride solution and one drop of the indicator. The suspension should then be titrated with the standard acid with vigorous shaking until the blue color is discharged. Add a further drop of indicator and continue titration. The end point is taken when the color changes from a definite blue to practically white; this occurs comparatively sharply over a few tenths of a c.c. of titrating acid. The end point is a little slower when large amounts of sodium carbonate are present, but an accuracy within 1 grm. per liter is easily obtained.

1 c.c. of 0.1 N HCl = 0.004 grm. caustic soda;
= 0.8 grm. free caustic per liter (on a 5-c.c. sample).

Note.—It is sometimes recommended to filter out the precipitate before titration, but in the process, CO_2 from the air may neutralize some of the caustic and it is found that the retention of the precipitate does not affect the accuracy of the determination.

Tin Concentration (Stannate Content).

The most suitable methods are based on the reduction of the tin to stannous chloride followed by titration with standard iodine. The standard methods of reduction with nickel sheet or powdered antimony as found in text-books may be used, but perhaps the most convenient method for routine analysis is the reduction with sodium hypophosphite.*

Reagents required:—

(1) Sodium hypophosphite	5 grm. for each estimation (a suitable measure may be used instead of weighing).
(2) Hydrochloric acid	50 c.c. concentrated acid, plus 50 c.c. water.

*B. S. Evans, *Analyst*, 1931, **56**, 171.

(3)	Mercuric chloride	a saturated solution.
(4)	Citric acid	50 grm. to 100 c.c. water.
(5)	Potassium iodide	4 per cent.
(6)	Starch indicator	——
(7)	Standard iodine solution	0.1N.

The apparatus is a large conical flask fitted with a three-holed bung, see Fig. 2. The first hole carries a tube to pass in CO_2, the second a tap funnel, and the third is used to insert the burette and is kept closed with a glass rod when not in use.

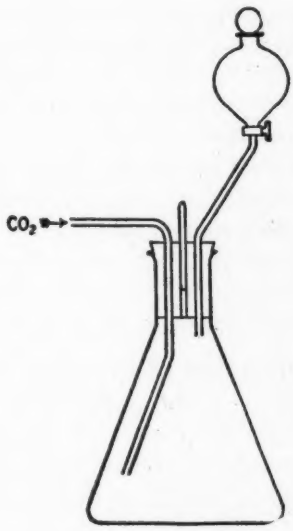

FIG. 2—Apparatus for tin determination.

Dissolve a 5-c.c. sample of the bath in 20 c.c. of hydrochloric acid in the flask and then pass a rapid stream of CO_2, say for 5 minutes, to expel all air from the apparatus. After this, the CO_2 may be turned down to a slow stream, which should be kept passing during the subsequent reduction and titration in order to ensure that no air enters the apparatus. Now add 5 grm. sodium hypophosphite dissolved in 80 c.c. hydrochloric acid and then 1 c.c. of mercuric chloride. Boil gently for 20 minutes. Meanwhile, take 10 c.c. of potassium iodide, 50 c.c. of citric acid and 1 c.c. of starch, dilute to 250 c.c. and boil to expel dissolved air, then cool somewhat. When the flask is removed from the

flame add this solution and allow to cool. When cold, titrate with standard iodine, inserting the jet of the burette through the stopper. The end point is taken when the first permanent blue color is obtained.

1 c.c. of 0.1 N Iodine = 0.00593 grm. of tin;
= 1.19 grm. of tin per liter on a 5-c.c. sample.

Tin Concentration—Simplified Determination.

To avoid the use of an external supply of CO_2, the following modifications can be made to the above. The results agree within 1 grm. per liter, the modified method being about 0.5 grm. per liter too low.

The flask should be fitted with a rubber bung with one hole only carrying a glass tube drawn out to a jet at its outer end. After the flask has been boiled for 10 minutes and the potassium iodide, citric acid, and starch solution added, drop in about 10 grm. of marble, replace the stopper and cool quickly under a tap. When cold remove the glass tube and insert the burette, and titrate. To prevent appreciable oxidation, it is necessary to avoid violent agitation both during cooling and titrating.

Stannous Tin (Detection of Stannite.

Stannite contamination can be estimated by acidifying a 10 or 25 cc. sample with 20 per cent hydrochloric acid and then titrating directly with N/100 iodine, using starch as an indicator.

1 c.c. N/100 iodine = 0.0006 grm. stannous tin;
= 0.06 grm. per liter on 10-c.c. sample.

A titration of over 0.1 c.c. indicates the presence of stannite to an objectionable degree.

The presence of traces of stannite is quickly noted by an experienced operator without chemical tsting, as the coatings will show slight roughness, especially at the edges and corners or on the suspension wires, and the color of the bath changes from a clear or slightly milky white color to a greyish tinge. Often in commercial baths the first traces of stannite produce a characteristic pink color, due to stannostannic complexes. This pink color though a very definite indication of stannite does not occur in all baths.

Sodium Carbonate.

This determination is required only after many additions of

free caustic have been made, and standard methods, based on the evolution of CO_2, are applicable to this bath.

Note on Commercial Sodium Stannate.

The composition of commercial sodium stannate corresponds approximately to the trihydrate—$Na_2SnO_3 3H_2O$, but its quality may vary considerably according to the method of production. Two grades frequently supplied contain 30 per cent to 34 per cent tin and 40 per cent to 44 per cent tin, respectively, together with some 3 to 6 per cent of caustic soda.

Usually the impurities present in commercial stannate are not harmful in the plating bath, but occasionally they may cause troubles. Oxidizing agents tend to lower the cathode efficiency of stannate baths. Sodium nitrate if present to the extent of 2 grm. per liter will lower the efficiency by about 20 per cent, while 20 grm. per liter will reduce the efficiency by 80 per cent. Its adverse effect, however, wears off gradually when the bath is in use. Chlorides are not harmful in the plating bath unless present in very large amounts (e.g. over 50 grm. per liter), when they can cause a slow breakdown of the oxide film on the tin anodes. Small amounts of metallic impurities are harmful only if they are soluble in the alkaline solution, like antimony, arsenic, or, in a less degree, lead. Small amounts of these metals if present will tend to plate out on the cathode and cause dark coatings to be formed.

Detection of Impurities in Commercial Stannate.

(1) *Nitrates.* A sample of the stannate is warmed with a few c.c. of caustic soda solution and a piece of aluminum in a small flask. If nitrates are present ammonia is evolved, which can be detected by its smell or with litmus paper. Using a 5-grm. sample of stannate, sodium nitrate can be detected when present to the extent of 1 per cent or over.

(2) *Antimony and Arsenic.* A simple method is to place a copper strip (cleaned by dipping in citric acid) in a sample of the stannate dissolved in hydrochloric acid. On warming, metallic antimony or arsenic is precipitated as a grey coating on the copper. (In small amounts antimony appears as a characteristic purple color—Cu_2Sb.) Dissolving a 1-grm. sample of stannate in 5 c.c. water plus 5 c.c. hydrochloric acid, it is possible to detect antimony or arsenic if present to the extent of 0.2 per cent or over. (The metallic precipitate should not be confused with a

slight blackening which occurs if the copper is tending to dissolve in the hydrochloric acid due to the presence of an oxidizing agent, e.g. nitrate or hydrogen peroxide.)

(3) *Lead.* Dissolve a sample of stannate in a few c.c. of caustic soda solution (5 per cent), filter, and add one or two drops of dilute ammonium sulphide. Using a 1-grm. sample of stannate dissolved in 10 c.c., 0.05 per cent lead or more gives a distinct black precipitate.

Maintenance of Automatic Stannate Electro-tinning Baths.

Good work, free from roughness and of uniform coating thickness can be produced unfailingly from sodium stannate plating baths, *without* additions of oxidizing agents, if the anodes are kept properly filmed.

Conditions for properly forming and maintaining this film are explained in our publications Nos. 82 and 92, but these are the salient points:—

1. Anode current density must be balanced against free caustic content, temperature and tin content of the bath according to the table:—

Tin Content	*Temperature* Limits ± 2°C	*Free Caustic Soda* Limits ± 1g.p.l.	*Anode Current* Density* (normal operating value)
25 g./litre	75°C	10 g./litre	30-35 Amps/sq.ft.
	80°C	9 "	35-40 "
33 g./litre	70°C	11 g./litre	30-35 "
	75°C	10 "	35-40 "
	80°C	9 "	40-45 "
40 g./litre	70°C	12 "	35-40 "
	75°C	11 "	40-45 "
	80°C	10 "	45-50 "
50 g./litre	70°C	15 "	45-50 "
	75°C	14 "	50-55 "

*Calculated on surfaces of anodes facing work (i.e. omit areas of back of anodes when alongside the tank sides but include when anodes face work on both sides.

NOTE. Anode current densities are based on the assumption that the plating solution contains at least 5% sodium carbonate. For new solutions practically free from carbonates the anode current density must be increased by about 5 amps/sq.ft.

2. Anodes must be positively connected to bus bars, by welding, bolting or some equally certain method. Loose connections invariably lead to the formation of stannite, rough deposits and loss of tin from the electrolyte.

3. Anodes must be narrow (not more than 6" wide) and well-spaced from sides of tank, heating coils, etc.:

4. When starting up or shutting down, dummies or blanks must be hung on the cathode hooks to maintain a constant cathode area.

5. When starting, the current density must be in excess of the normal operating current density in order to form a film immediately. Working within the limits given in the table, this excess will not exceed $66\frac{2}{3}\%$. Correct filming of the anodes is indicated by a rapid rise in the voltage between anodes and cathodes (by about two volts) with a corresponding fall in current. When the voltage reaches a steady value, usually within 2 minutes, the current is reduced to the figure given in the table.

   (*Note*: If not so reduced the anodes may become passive.)

   If sufficient current for the brief starting overload is not available, provision must be made to withdraw enough anodes to raise the current density on the remainder to the desired value. Directly, these latter have filmed the others may be lowered slowly into the bath, making sure that they are at all times connected to the anode bus bar.

6. Tin content of the bath must be maintained to compensate for "drag-out".

7. Cathode current density may vary between 15 and 25 amps./sq.ft.

If the above simple routine is followed and controlled by regular analyses for free caustic and tin, it will be found that oxidizing agents are only needed when there has been an accident (work falling into the vat and becoming anodic, etc.) or a mistake.

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On U. S. Army tanks, the rims of the "bogie wheels" are brass-plated before their rubber "shoes" are put on. If the brass-plating is unsatisfactory, a poor rubber-coating job results.

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Drag-In

JOSEPH B. KUSHNER, CH. E.
Metal Finishing Consultant
New York City

IT is only about a decade and a half since we first started considering the effects of drag-out in electroplating. In 1928 Nixon[1] presented a paper in this journal on the subject of drag-out in which he showed that a substantial loss of valuable salts could occur through this agency. In 1935 the writer[2] analyzed drag-out mathematically and worked out a formula whereby drag-out losses could be simply computed. Then followed in quick succession a number of papers on the same subject, all showing what losses could occur because of drag-out and what steps could be taken to prevent them or at least reduce them.[3] Now that we are in the war and every vital metal and chemical must be conserved, drag-out, originally thought to be of importance only to precious metal platers, has suddenly become important to every plater.

Thus we have presently concerned ourselves with the little drops of liquid we take out of the plating bath, drag-out—BUT —HOW about the little drops of water we put into the plating tank, drag-in? To the best of our knowledge nothing was written on this subject until 1939 when Hogaboom[4] published his thought provoking study, "Water in the Plating Room." His parting sentence in that paper, which I recommend to every progressive plater for reading, is: "The big unsolved problem of the plating room is water." There can be no doubt about it—water can be the cause of many plating headaches, headaches often ascribed to other causes.

We go to see a movie murder mystery thriller or read a "whodunit" and immediately spot the most innocent looking character as the villian of the piece, but in the plating room we overlook that most innocent appearing character of all—water—a villian that has killed more plating baths than you and I will ever know

1. C. F. Nixon, *Monthly Review*, March, 1928.
2. J. B. Kushner, *Metal Industry*, January, 1935.
3. G. B. Hogaboom, *Metal Cleaning & Finishing*, Oct., 1936.
   G. Soderberg, *Proceedings National Convention*, 1937.
   Charles C. Conley, *Monthly Review*, May 1939.
   J. B. Kushner, *Metal Finishing*, August, 1939.

about! And no wonder. If the water in the plating room is good enough to drink we can hardly believe that it may be bad for the plating tanks. But it is.

In his paper[4] Hogaboom gives numerous examples of how water caused difficulties in a number of plating rooms. He shows how water made the pH of a plating bath erratic, how it caused a bright nickel solution to plate dull, how it caused polarization of anodes, just to mention a few. The present writer, in a paper published contemporaneously with this one[5] gives an example of how a gold plating bath was ruined by water drag-in and finished work that was spoiled the same way.

Consider what you may find in raw tap water and that this tap water makes up from 80 to 90 percent of our plating baths and you will realize why it can do harm:

POSSIBLE IMPURITIES IN RAW WATER

Dissolved solids	Suspended solids	Dissolved gases
Calcium	Dirt	Hydrogen sulphide
Copper	Rust	Carbon dioxide
Magnesium	Inorganic and or-	Ammonia
Iron	ganic colloidal matter	Sulphur dioxide
Manganese		chlorine
sodium		oxygen
potassium		
bicarbonates		
carbonates		
chlorides		
sulphates		
organic acids and salts		

Take a salt like calcium bicarbonate for example. This salt is often found in raw water. What can it do to a plating bath? If the bath is of the acid type such as nickel or acid copper, it will combine with the free acid, thus increasing the pH of the solution and at the same time forming soluble calcium salts that may be highly detrimental to the plate, as calcium is, in many bright nickel solutions. The equation of the reaction in a bright nickel bath, shows what happens:

(1) $Ca(HCO_3)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O + 2CO_2$

In an alkaline or cyanide plating solution calcium bicarbonate is just as bad, if not worse. Here, it *lowers* the pH, destroys free cyanide and helps build up sludge and unwanted carbonates.

4. G. B. Hogaboom, *Metal Finishing*, April, 1933.
5. J. B. Kushner, *Products Finishing*, July 1942.

The equation shows why:

$$(2)\quad Ca(HCO_3)_2 + 2KCN \rightarrow \underset{\downarrow \text{ precipitate}}{CaCO_3} + K_2CO_3 + \underset{\uparrow \text{ Gas}}{2HCN}$$

What about other impurities in tap water? Iron for instance? Every plater knows the hob it raises in an acid or alkaline copper plating solution. What about copper? We all know what copper does to a nickel bath. What about chlorides? Every plater knows how chlorides can pit and corrode supposedly insoluble anodes such as stainless steel. We could go on this way indefinitely but there is no need to because the plater who has experienced some of these headaches knows them well.

It is true that the concentrations of some of these substances in raw water is very low and possibly many may not even be present at all, but, wherever they are found in water, even in the smallest concentrations, they can do harm to susceptible plating baths because they build up by drag-in much more rapidly than is commonly suspected, as we will prove in a few moments. That substances present in such small amounts in the tap water can have an effect on the plate is often doubted by many platers, but we don't have to go far from home to prove that this is so. Take the case of brightener in a silver plating solution. The average recommended concentration of carbon disulphide to give a semi-bright plate of silver is about .0001 oz/gal.* If this amount is exceeded by even a tiny margin, the silver deposit becomes hard and discolored.

Let us translate this concentration into units used for giving solids content of raw waters: parts per million (equivalent to milligrams per liter of solution). The result is that the carbon disulphide concentration is .75 ppm! Most raw waters have total solids contents of 50 ppm and more! If only .75 ppm of carbon disulphide can have such a marked effect on a silver bath, isn't it logical to assume that other substances of the same and greater orders of magnitude can also have large effects on the plating bath?

If we are willing to concede that small amounts of dissolved and undissolved substances present in raw water can have large effects in the plating bath, then the next thing to know is how

Plater's Guide Book 1937, Page 24.

these substances build up to dangerous concentrations in the plating bath, by drag-in.

We are now going to give a method for determining the manner in which harmful salts and ions can build up by drag-in in the plating bath. Its derivation involves some fairly advanced mathematics the use of which could not be avoided. This mathematics is given here in brief outline for those who will want to know how we reached our conclusions. We therefore suggest that those of you who do not care for figures skip this section entirely and go right on to the practical applications of this analysis.

AN ANALYSIS OF DRAG-IN

In order to proceed, a few assumptions must be made. These assumptions are:

1. In plating plants where a large number of pieces or racks are plated daily, the operation of rinsing the work, putting it into the plating bath and withdrawing it, can be treated as a continuous process, i.e., like the flow of water in a pipe, as far as the liquid that clings to the racks (drag-in and drag-out) is concerned. This assumption can be justified mathematically but its justification will not be gone into here*.[1,2]

2. The liquid volume from the drag-in of any number of pieces is equal on the average to the liquid volume of the drag-out from the same number of pieces.

3. Water is list from the plating bath only by evaporation. This water lost may be replenished continuously as is sometimes done in automatic plating installations, or it may be replenished intermittently, from day to day at the start of the working day, or during the day.

NOMENCLATURE

n_1 = average number of pieces or racks plated daily, or in the period under consideration.
x = the number of days of operation.
N = n_1x, the total number of pieces plated in x days.
V = volume of the plating solution at any time during the day, after n plating racks have passed through it.
V_1 = The volume of the plating solution when it must be replenished at the end of the operating day or a given period of time after n_1 racks have passed through.
V_0 = The volume of the plating solution at correct operating height at the start of the day, or plating operations.

*1. Those interested can consult Sokolnikoff, *Higher Mathematics For Engineers*, McGraw Hill, Chapter on Probability to see why this is so.
2. The, tacit assumption, that the foreign ion is not being plated out, is also being made.

a = The volume of drag-in or drag-out per rack plated.

b = The volume of plating solution evaporated per rack plated. In other words: $b = \frac{V_0 - V_1}{n_1}$

C = the concentration of the salt or ion we are studying, in the plating bath, after n racks have gone into the bath.

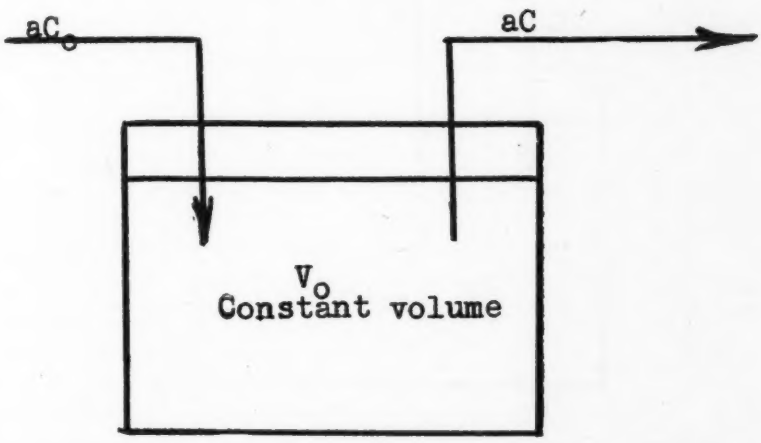
C_0 = the concentration of the salt or ion, in the tap water used for rinsing.

C_1 = The initial concentration of the salt or ion in the plating bath at the start of operations.

CASE I NO EVAPORATION OCCURS

Consider the plating tank shown in figure 1. Tap water containing a harmful ion is carried into the bath by drag-in and plating solution is carried out of the bath by drag-out. The concentration of the harmful ion in the tap water is C_o grams per liter. No matter what the concentration of this harmful

FIGURE NO. 1
CASE I No Evaporation takes place.



ion is in the plating bath at the start, common sense tells us that if there were absolutely no evaporation of water from the plating tank (in actual practice this never occurs— even in room temperature solutions), eventually, the concentration of the ion in the plating tank will build up or down to C_o grams per liter. That common sense gives the correct answer in this case can be

proven at once by setting up the differential equal for the process, remembering it is a continuous one.

Doing this we get:

$$(1E) \quad V_o \frac{dC}{dN} = aC_o - aC$$

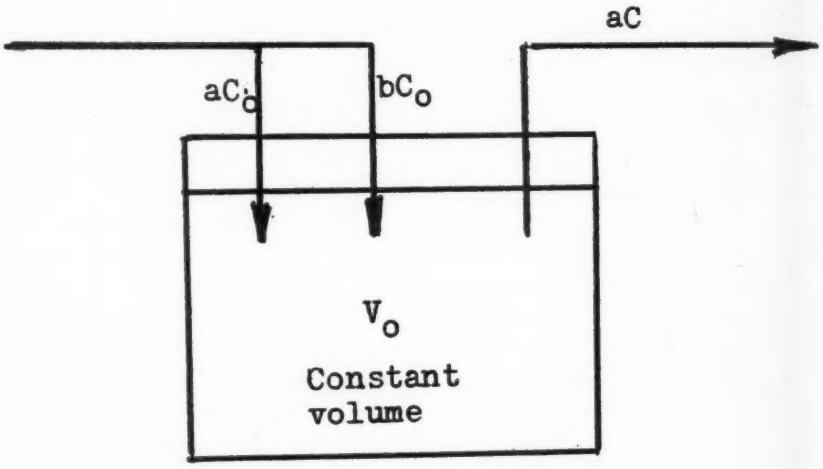
Which mathematically states that the increase in the given ion in the plating bath during the time we plate 1 rack is equal to the amount of the ion we carry in minus the amount we drag-out.

Solving this equation by straightforward methods found in any text, we get:

$$(2) \quad C_x = C_o - (C_o - C_i)e^{-an_1 x/V_o}$$

where C_x is the concentration of the ion in the bath on the xth day and e is the base of natural logarithms, 2.178.

FIGURE NO. 3
CASE II Evaporating water constantly replenished.

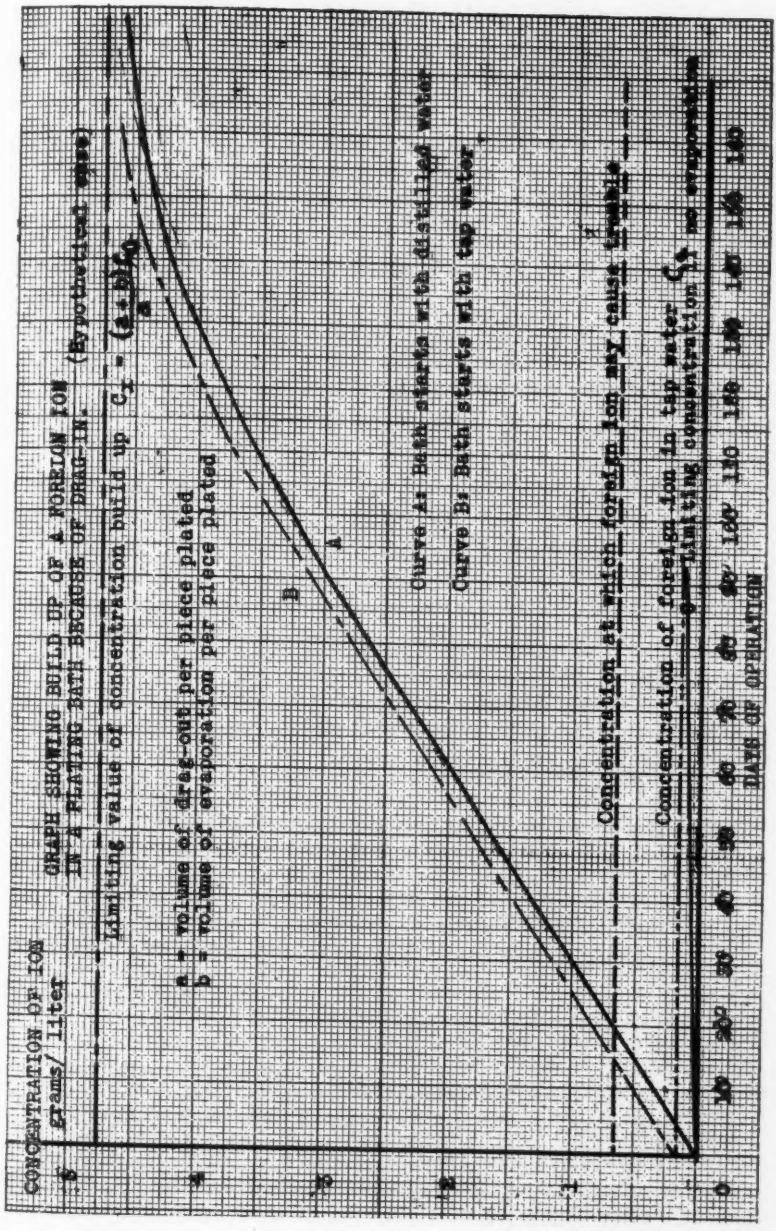


As can be seen at once as x gets larger the e term gets smaller and smaller until it becomes equivalent to zero. This means, therefore, that after a large number of racks are plated, the term in parentheses will vanish and in the limit,

$$(3E) \quad C = C_o,$$

or, the concentration of the ion in the tank will become equal to its concentration in the rinse water. The graph of this equation is shown in figure 2, at the very bottom.

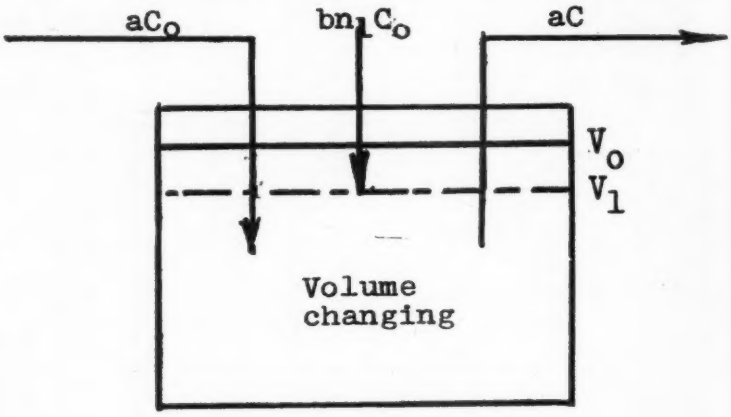
FIGURE NO. 2


GRAPH SHOWING BUILD UP OF A FOREIGN ION
IN A PLATING BATH BECAUSE OF DRAG-IN. (Hypothetical case)
Limiting value of concentration build up $C_x = \frac{(a+b)C_0}{a}$
a = volume of drag-out per piece plated
b = volume of evaporation per piece plated
Curve A: Bath starts with distilled water
Curve B: Bath starts with tap water
Concentration at which foreign ion may cause trouble
Concentration of foreign ion in tap water C_0, no evaporation
Limiting concentration
CONCENTRATION OF ION grams/liter
DAYS OF OPERATION

CASE II EVAPORATION LOSSES CONTINUOUSLY REPLENISHED

Consider the automatic plating tank shown in figure 3. Tap water containing a harmful ion goes into the plating tank in two ways: By drag-in and as a replenishment for evaporation. The harmful ion leaves only by drag-out. Since the volume

FIGURE NO. 4
CASE III Evaporating water intermittently replenished.



of solution is maintained continuously at the same level, we can immediately set up the differential equation of the process:

(4E) $V_o \frac{dC}{dN} = aC_o + bC_0 - aC$

The solution of this equation by regular procedure is:

(5E) $C_x = \frac{(a+b)}{a}C_o - [\frac{(a+b)}{sa}C_o - C_i]e^{-an,x/V_o}$

for the same reason as before, as x gets larger, e goes to zero and the term on the x extreme right vanishes. In the limit we get:

(6E) $C_x = \frac{(a+b)}{a} C_o$

This means that if our evaporation rate is much higher than our rate of drag-out we can build up tremendous concentrations of the harmful ion in relatively short periods of time! For example in a cleaning solution running at 200°F, the evaporation rate per piece plated may be as much as a thousand times the

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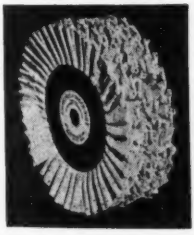

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drag-out per piece plated, with a result that the ion in the tap water may be concentrated to a thousand times that strength in the cleaning tank! This may explain why cleaning baths in certain localities go bad much sooner under approximately the same average load than cleaning baths made of the same ingredients in other regions.

CASE III EVAPORATION LOSSES INTERMITTENTLY REPLENISHED

This is the most general and practical case since in almost all plating plants evaporated water is replenished once or twice a day in preference to using a controlled water feed to the plating or cleaning tank. For our purposes we shall assume that the plater replenishes the plating bath with water once a day at the start of operations (it can be shown that whether the plating bath is replenished daily or twice daily, etc., the ultimate result is the same!)

Consider the plating tank shown (figure 4). Tap water goes in by drag-in as the volume of the bath changes, due to continuous evaporation. The ion under consideration leaves only through drag-out. Making use of the law of continuity and allowing for the fact that the tank volume is changing we can set up the following differential equation:

$$(7E) \quad \frac{d(VC)}{dn} = aC_0 - aC$$

We have to take the derative with respect to n this time, the number of pieces that have passed through the tank after any time during a given day, because the tank volume is changing. Solving this equation in the usual manner er get:

$$(8E) \quad C = C_i\left(\frac{(V_0 - bn)}{V_0}\right)^{a/b-1} + \left(\frac{a}{b-a}\right) C_0 \left[\left(\frac{V_0 - bn}{V_0}\right)^{a/b-1} - 1\right]$$

This equation will give the concentration of the ion at any time during a given day, or period and will hold until the end of the day or period when $n = n_1$. The next day or period the water is replaced in the tank, bringing tank volume back to normal, V_0. This means we add a total of bn_1C_0 ions to the bath. Because of this, we have to set up the same differential equation for the second day, or period except that now the initial concentration of the harmful ion is that the day, or period before,

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A final drying at 170° to 180° Fahrenheit with 50% or less humidity makes for optimum results. This is IMPORTANT. (Increased temperature alone will improve the efficiency of the wheel head to a lesser degree than when the high temperature is accompanied by a low humidity.)

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plus what was put in, in replenishing the evaporated water. If this procedure is followed mathematically from period to period, we obtain what is known as a recursive series. The series turns out to be a geometric series and can be summed in finite terms. The job is particularly tedious but it can be shown that at the end of the xth day the concentration of the harmful ion in the tank is, with respect to the correct volume, V_0:

$$(9E)\quad C_x = C_i R^{\frac{xa}{b}} + C_0\left[(1-R)+\frac{a}{b-a}(R^{a/b}-R)\left[\frac{1-R^{\frac{xa}{b}}}{1-R^{a/b}}\right]\right]$$

Where $R = \dfrac{V_0 - bn_1}{V_0}$ or $1 - bn_1/V_0$

This equation looks complicated but it is amendable to considerable simplification. Let us see, for example, what will happen, as x gets larger, i. e. as we approach the limit.

Since R is less than unity, the first term on the right will vanish, Similarly the $R^{\frac{xa}{b}}$ at the end disappears. Remembering that $R = 1 - \dfrac{bn_1}{V_o}$ and bn_1 will in general be fairly small as compared to V_o, we can simplify still further by using the approximation $R^{a/b} = (1 - \dfrac{bn_1}{V_o})^{a/b} = 1 - \dfrac{an_1}{V_o}$. If this is done throughout, we get as a final result:

$$(10E)\quad C_x = (\frac{a+b}{a})C_o\ !$$

This is a limiting value, the concentration that will be reached after many days of operation. This limiting value is the same as that for the continuous replenishment case II.(See graph).

We have seen that the limiting values of equations 5E and 8E are the same. Without much difficulty it can be shown that both equations are equivalent, or approximately the same, for if both are simplified by the use of the approximations $e^{-\frac{an_1 x}{V_o}} = 1 - \dfrac{an_1 x}{V_o}$ and $(1 - \dfrac{bn_1}{V_o})^{ax/b} = 1 - \dfrac{an_1 x}{V_o}$ (where x is small), we get the same final result from equations 5E and 8E, namely:

$$(11E)\quad C_x = C_i(1 - \frac{an_1 x}{V_o}) + (a+b)\frac{n_1 x C_o}{V_o}$$

This equation can be rearranged as the equation of a straight line, by factoring, and we get finally:

$$(12E)\quad C_x = C_i + \frac{n_1}{V_o}[(a+b)C_o - aC_i]x$$

This is the simplified general law of drag-in from which the rate at which a given ion builds up in the tank can be determined.

Equation 12E has two special cases. In gold plating and many other types of precious metal plating, pure distilled water is used in making up the bath. This means, if the harmful ion is not present in the plating salts, when first dissolved, $C_i = O$, and

$$(13E)\quad C_x = \frac{n_1}{V_o}(a+b)\,xC_o$$

If, as is usual practice in most other types of plating, tap water is used for making up the bath, $C_i = C_o$, and

$$(14E)\quad C_x = \frac{C_o\,(1+n_1bx)}{V_o}$$

With equations 12E, 13E and 14E we can solve any problem involving drag-in.

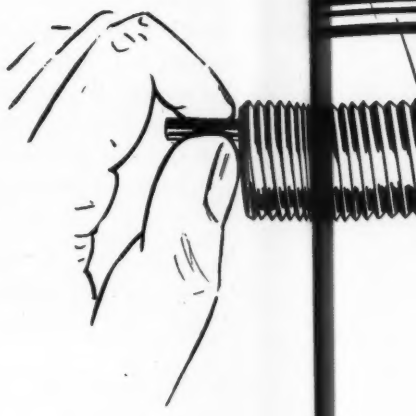
PRACTICAL APPLICATIONS

In order to make use of the drag-in equation, you must know the following: 1. The analysis of your plating room water. This can generally be gotten free of charge from your local water company for the asking, or if you have your own water source, a chemist can be called in to analyse it for you.

2. The number of pieces or racks on the average that you plate daily.

3. The volume or amount of water evaporated per rack plated. This figure can be gotten in several ways. Here is how: If water is replenished continuously and automatically a water meter can be put on the feed line and the daily reading taken; the water used in 1 day divided by the number of racks or pieces plated per day is equal to b. If water is replenished intermittently, you can get the value of b by starting the plating day with the tank volume at proper operating level, V_o. Put a yardstick into the tank and measure the height of the solution. Now work the tank, keeping a tally of the number of racks or pieces plated. When the volume of the plating bath goes down to a point where you have to replenish again with water V_o, put in the yardstick and measure the depth of the solution. If you

...and off comes the BURR....



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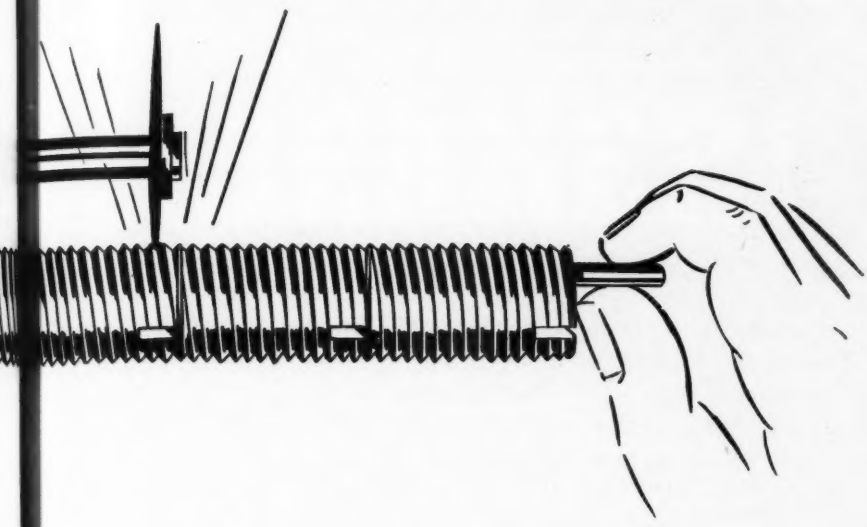

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know what the original or proper operating volume is, V_o, obtained by measuring the tank, then the amount of water that has evaported is equal to V_o multiplied by minus the depth of the solution after the run, over the depth of the solution befort the run. The volume of water evaporated obtained in this fashion can then be divided by the number of racks or pieces plated up to that time to give b.

An example will make this clear. Let us suppose a plater has tank in which the solution when up to the mark totals 100 gallons. The depth of the solution as measured at that time with a yardstick is 24 inches. After operating the solution for 3 hours 300 racks have gone through and the solution must be replenished with water (hot bath) as the height of the solution is now down to near the top of the racks. At this point the yardstick shows a measurement of 20 inches. The amount of water that has evaporated up to this point, therefore, is 100 (1—20/24), which equals 16.67 gallons. Since in this time 300 racks have been plated, b=16.67/300=.0556 gal./rack.

4. The fourth and last item that must be known is the drag-out per rack or piece. This can be obtained in several ways, among which are the methods of Conley[6], Kushner[7], Hogaboom[8] and Nixon[1]. In a pinch, to get a rough result, the volume of drag-out per rack may be approximated by using figures given by Soderberg[9], i.e., .0004 to .024 gal. per sq. ft. of plating surface, depending on whether the work is flat or cup shaped, and care in draining. If the bath is made up with tap water, the drag-out need not be known at all.

USE OF THE DRAG-IN EQUATION

EXAMPLE I. A manufacturer is plating 20,000 pieces of work daily in a gold plating solution that was originally made up by using distilled water. His rinse water is drawn from a private well. The volume of the gold plating solution when up to par is 50 gallons. His plater noted that the bath which is supposed to run at a free cyanide concentration of 2 grams per liter (we are using metric system for simplicity) consumes excessive amounts of cyanide and builds up a sludge quickly, requiring time for filtration. We were called in to check up. The first thing that was done was to obtian the well water analysis. This

6, 7, 8, 9. See note 3, previous.

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showed a calcium bicarbonate content of 250 ppm (very hard water)! The drag-out per piece was by a rough determination approximately 1 drop per piece, or .05 cc., equivalent to .00005 liters (1 drop is about 1/20 cc.). By using the yardstick method for determining b it was found that the liquid height dropped from 20″ at full volume to 16″ while 4000 pieces were being plated. This means b is equal to $\frac{50(1-16/20)}{4000}$ = .0025 gallons or .0025 X 3.8 = .0095 liters. Using formula 13E, the calcium bicarbonate concentration after 1 days operation is:

$$C_x = \frac{.25 \text{ X } 20{,}000}{50 \text{ X } 3.8} (.0095 + .00005) = .25$$ grams of calcium bicarbonate per liter.

On the basis of the reaction between the bicarbonate and cyanide (see equation 2) we know that 1 weight of bicarbonate will destroy .8 weights of cyanide and will form .85 weights of soluble carbonate and .61 weights of insoluble carbonate or sludge. This means then, that in this particular case, the drag-in will destroy .2 grams per liter of cyanide in the plating bath, will build up .21 grams per liter of carbonate and will form .15 grams per liter of sludge! In ten days the carbonate concentration in the tank will be close to 2.1 grams per liter and the sludge (calcium carbonate) close to 1.5 grams per liter! No wonder the bath went bad!

EXAMPLE II. A plater is using a 1000 gallon bright nickel bath that is sensitive to .002 oz./gal. copper. If the copper concentration reaches this point in the bath the plate gets dark and cloudy and the bath must be dummied. Because of a copper sulphate treatment for algae in the local water, the copper ion concentration in the water is .0001 oz./gal. The bath is originally make up with tap water and is continually replenished with an automatic water feed pipe. A water meter on the line shows 400 gallons are used up daily. The number of racks plated daily is 2000. In how many days will the nickel solution go bad because of copper build up?

Using equation 14E and solving for x, we get:

$$(15E) \quad x = \frac{(C_x - C_o)}{n_1 b\, C_o} V_o$$

$C_x = .002$ oz./gal, $C_o = .0001$ oz/gal. $b = \frac{400}{2000} = .2$ gal.

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so $X = \frac{(.002 - .0001)\ 1000}{2000 \times .2 \times .0001} = 47.5$ days.

It should be remembered of course that this answer and the one in the previous example, are only approximations, due to the fact that we are using the simplified equations. If greater accuracy is required equation 5E will be sufficiently accurate for the purpose. However, for most occasions the simplified equations will do.

The few examples given here indicate the way in which drag-in of foreign ions may effect the plating bath, and the manner in which such drag-in can be computed. We firmly believe that as time goes on more and more attention is going to be paid to this subject by the practical plater.

MEMBERSHIP

We are beginning the activities of another year. Let's get off to a good start by aligning each Branch properly, so that our membership will continue to grow. Let's not let the good record of the past carry us without special effort to create interest for prospective members.

At the meeting of the Executive Board following the Convention — I was again appointed Chairman of the Membership Committee. Therefore, I am endeavoring to remind each Branch that the time to think of new members is now — at the very first meeting of the year.

The A.E.S. increased its total membership during the 1940-1941 year by 15.0%, or 350 members. During the 1941-1942 year, the membership was increased 12.3%, or 313 members. This is a good record, but only a beginning, if each Branch could somehow get the proper enthusiasm.

Remember, when thinking of inviting business friends who are interested in electroplating and its related subjects — there is absolutely no other Organization which offers the advantages we obtain as A.E.S. members. Some of these advantages can be listed as follows—

1. Technical information from speakers
2. Technical information from associations
3. Technical information from questions and answers, asked publicly at the meetings.
4. Fellow members represent majority of plating plants. This increases value of contacts made at meetings. Also information gotten is generally closely related to actual practice.
5. Techincal information from the REVIEW
6. Technical information at the Convention
7. Social contacts at various gatherings. This is most valuable, as a friend is worth having when you need assistance on the job.
8. Honest to goodness fun — at the dinner dances, regional meetings, and conventions.

Chairman of each Branch — will you please do this at your first meeting — if possible:

Discuss your tentative membership campaign. Have the 2nd Vice President take charge of this as he is automatically in charge of this function. After taking care of the above, kindly inform the writer as to the 2nd Vice Presidents name, address, etc.

Through the proper educational meetings and good fellowship we can increase our membership by not less than 15% for the coming year. It all depends on you!

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*See article in June MONTHLY REVIEW page 493.

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Supplies and War Production

By W. D. STARR
The Lea Mfg. Co., Waterbury, Conn.

Notes on Zinc

It is very doubtful that even Sherlock Holmes could find any significant amount of electroplating now being done on articles for civilian consumption. Most of the plating metals are definitely reserved for war production. Also General Preference Order M-126 prohibits the use of the common base metals, steel, for most civilian items. Even where steel is not specifically prohibited, just try and get it without a higher priority rating than could be assigned to a civilian order!

A short time ago we had our eye on zinc which was reasonably plentiful and which could be used without restriction. As of September 1, 1942, no zinc can be used in fabricating or plating a long list of items ranging from caskets to spittoons. All ornamental and decorative uses of zinc are "out" for the duration.

So zinc joins the list of metals reserved principally for combat equipment items. Although deliveries of zinc anodes are fairly dependable, none of the metal can be obtained without approval from Washington. Orders placed early in any month will be delivered the following month provided War Production Board approval is given. The supply and distribution of zinc is covered by General Preference Order M-11 while the restrictions on its use are set forth in Conservation Order M-11-b. Anyone plating with zinc should become familiar with these regulations.

EMERGENCY EXECUTIVE BOARD MEETING AUGUST 29, 1942

Due to the emergency brought about by the death of the former executive secretary and editor, Mr. Kennedy, an emergency executive board meeting was held on August 29. At that meeting the following appointments were made.

Mr. Jack Bain publisher of the MONTHLY REVIEW.

E. T. Candee acting secretary and editor of the REVIEW until a permanent executive editor is found.

The Society will establish offices at 545 Fifth Ave., Rooms 109 and 110, New York under the direction of Mr. Bain, for the conduct of the business of the Society. All business matters concerned for the Branch and National Society should be addressed to the New York office. Matters concerning the editor of the REVIEW and the Secretary should be addressed to Mr. Candee.

CONVENTION COMMITTEE

Four members of the Convention Committee under the chairmanship of Dr. Wernlund met with executive committee on August 29 to discuss convention plans. The Convention Committee is progressing satisfactorily under the direction of Dr. Wernlund and the executive committee is pleased with their progress to date.

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The Fundamentals of Electrochemistry and Electrodeposition

XI. The Significance of Reversible Electrode Potentials

Part X appeared in the May 1942 issue of the Monthly Review

By SAMUEL GLASSTONE
D. Sc., Ph. D.
Professor of Chemistry
The University of Oklahoma
Norman, Oklahoma

IN most of the previous articles we have considered various properties of the solutions that are employed in electrolysis or electroplating; little or no reference has been made hitherto to the part played by the electrodes. In this and subsequent articles attention will be paid to this important aspect of electrochemistry. In order to pass an electric current through a solution it is necessary to insert at least two electrodes — an anode and a cathode — and it is the properties and behavior of these electrodes that we must now examine. To do this we will take each electrode separately and study it, first when it is placed in a solution with no current flowing, and then we shall consider what happens when a voltage is applied from an external source, such as a battery or dynamo, so that a current passes.

Potential Difference

If any metal is placed in a solution containing its own ions — suppose, for example, that a piece of copper is inserted in a solution of a copper salt — a definite "difference of potential" is set up between the metal and the solution. By a difference of potential, sometimes referred to as "potential difference", or just "potential", for short, is meant a partial separation of positive and negative charges at the surface of separation between the metal and the solution in which it is placed. The potential under consideration is believed to originate somewhat in the following manner. When in contact with the solution there is a definite tendency for each atom of the metal to lose

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one or more negative charges, or electrons, according to its valence, and to pass into solution in the form of ions (see Part I of this series, MONTHLY REVIEW, August 1941). For example, in the particular case of the metal copper, which we are considering, the ionization process represented by the equation

$$Cu\ (atom) = Cu^{++}\ (ion) + 2\ electrons$$

will occur at a definite rate, the metallic copper atoms passing into bivalent copper ions in solution. At the same time there will be a tendency for the copper ions already in the solution, which are produced by the ionization of the copper salt that is present, to undergo the reverse (discharge) reaction, thus

$$Cu^{++} + 2\ electrons = Cu,$$

so as to form metallic copper atoms on the electrode surface.

Reversible Potential

As a general rule these two opposing processes, which occur simultaneously, will not take place at the same rate. Let us suppose that the latter, that is the discharge of ions from solution, is the faster of the two; the result will be that more ions will leave the solution by one process than are returned to it by the reverse (ionization) process. As a consequence there will be a partial separation of charges, the metal becoming positively charged while the solution acquires, at least relatively, a negative charge. In other words, as a result of the difference in rates of the ionization and discharge processes, a difference of potential will be set up at the metal-electrolyte surface, the metal being positive with respect to the solution. The effect of this difference of potential is to facilitate the ionization process, while the reverse (discharge) process is retarded. Eventually a condition is reached at which, as a result of the operation of the potential difference, the ionization and discharge reactions take place at exactly the same rate. The system of metal and solutions will then be in equilibrium, and the potential difference under these conditions is called the "equilibrium potential" or "reversible potential" of the particular metal in the given solution. It should be mentioned that although it takes some time and many words to describe, the actual establishment of equilibrium between the metal and solution occurs instantaneously in the majority of cases.

A BASIC FACT REMAINS UNCHANGED

Even the shortage of metals in wartime has not changed the fact that electroplating is the best answer to many corrosion problems. The War Department and W. P. B. have recognized this and allocate metals for plating many parts on the machines of war. Hard, tough, resistant metal coatings have not been replaced satisfactorily - - they will take their place in post-war industry just as they have taken an important place in war.

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Noble and Base Metals

From what has been said in the previous paragraphs, it may be concluded that metals which have relatively little tendency to pass into solution as ions, such as copper, silver, mercury and gold, will acquire somewhat positive potentials, while metal which form ions readily, such as sodium, zinc, cadmium and iron, have negative potentials when immersed in the appropriate solutions. In other words, noble metals generally have postive potentials, while base metals acquire negative potentials. Further reference to this subject will be made in later articles, but at present it is necessary to consider another important aspect of the problem of potentials, namely the influence of the concentration of ions in solution. It will be shown that as a result of changing the copper ion concentration, the metal copper, generally regarded as a fairly noble metal and which has a positive potential in a solution of a simple copper salt, such as copper sulphate, can be made to assume a highly negative potential.

Influence of Concentration

Since a state of equilibrium under consideration depends on the rates of two opposing processes, it follows, in accordance with the fundamental principles of reaction rates, that it will be determined by the concentration of the metal atoms, on the one hand, and of the ions in solution, on the other hand. For the present it may be supposed that we are dealing with the metal in the pure state; consequently the concentration of metal atoms may be taken as constant. The concentration of ions in solution can, however, easily be varied over a considerable range; hence the condition of equilibrium, and as a result the equilibrium potential of a given metal, will vary as this concentration changes. By means of arguments based on thermodynamics, it can be shown that the reversible, or equilibrium, potential (E) acquired by a particular metal when placed in a solution containing its own ions at a concentration C, is given by the equation

$$E = E_0 + 2.303 \frac{RT}{zF} \log C,$$

where E_0 is an important constant for the given metal, known as its "standard potential". The other symbols in this equation are as follows: R is the so-called "gas constant", T is the ab-

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solute temperature, F is the Faraday, and z is the valence of the particular ions of the metal in the solution. (For a further discussion of some of these quantities see Part V, December 1941, and Part VIII, March 1942). As explained in Part VIII, in connection with the hydrogen electrode, which behaves in principle like the electrodes described in this article, by inserting the values of the constants R and F, and supposing that the temperature is about 22°C,that is 72° F, the equation for the electrode potential becomes

$$E = E_0 + \frac{0.059}{z} \log C.$$

Strictly speaking this equation is applicable if the solution exhibits what is called "ideal behavior". In other cases the actual concentration C should be replaced by an "ideal concentration" or "activity", which allows for the departure from ideal behavior. However, for present purposes, especially if the solutions are fairly dilute, it is unnecessary to take this refinement into consideration; C may therefore be taken as the actual concentration of the ions. In electrochemical equations it is the custom to express ionic concentrations in terms of "gram-ions per liter", and C is consequently stated in these units. If the salt present in the solution contains only one atom of the metal per molecule, as is the case with many common salts, e.g., $CuSO_4$, $NiCl_2$, $NiSO_4$, $FeCl_2$ and $ZnSO_4$, the concentration in gram-ions per liter is the same, apart from the allowance for incomplete ionization, as the usual expression of the concentration in gram-molecules (moles) per liter. If there is more than one atom of the metal in the molecule of salt, then the ionic concentration is obtained by multiplying the molecular concentration by the number of these atoms. Let us consider a particular example: in sodium sulphate, Na_2SO_4, there are two atoms of the metal sodium in a molecule of the salt, and so the concentration of sodium ions, in gram-ions per liter, is twice the concentration of the sodium sulphate in moles per liter, apart from a possible allowance for incomplete ionization of the salt.

There are a number of points of interest in connection with the equation for electrode potentials and these will be discussed in the next article in this series.

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Research Committee

It is sometimes well to look back and review what has been accomplished when research work has been carried on for fifteen years. By going over the work we can appreciate what has been done and also refresh our memory on the problems that have been solved by research work.

Back in the 1920's plating and lacquering rooms practically shut down for the months of July and August because of spotting out. Although this condition was worse on castings than on wrought metal the problem was so critical that many plants planned on building up stocks of finished parts in the fall, winter and spring and do no finishing in the summer. It was not uncommon in the summer months to plate or lacquer thousands of pieces, finish them up at 5 o'clock and come in in the morning and find one thousand spotted so badly that they had to be refinished. The discouraging part was that after they were refinished they would spot again.

The Research Association studied this problem at the National Bureau of Standards and first determined that there were two types of spotting; crystal spotting and stain spotting. The first was caused by sulphur either in the finish or in the wrapping that comes into contact with the finished part. This type of spotting which most commonly occurs on "oxidized" finishes, can very easily be eliminated by selection of materials that come in contact with the parts that are free of sulphur. The stain spotting was found to be caused by occluded cleaning salts or other chemicals in the pores of the metal absorbing moisture from the atmosphere, oozing out and corroding the metal.

Since it is not possible to make castings free from pores, not much help could be expected from the basis metal. However, it was found that certain changes in casting design reduced the number of pores and their reduced chances of spotting. It was also found possible to reduce spotting by using lacquer with a low moisture permeability.

Although a sure cure for spotting out was not found, enough information was obtained to reduce spotting out from a major problem to a mere nuisance.

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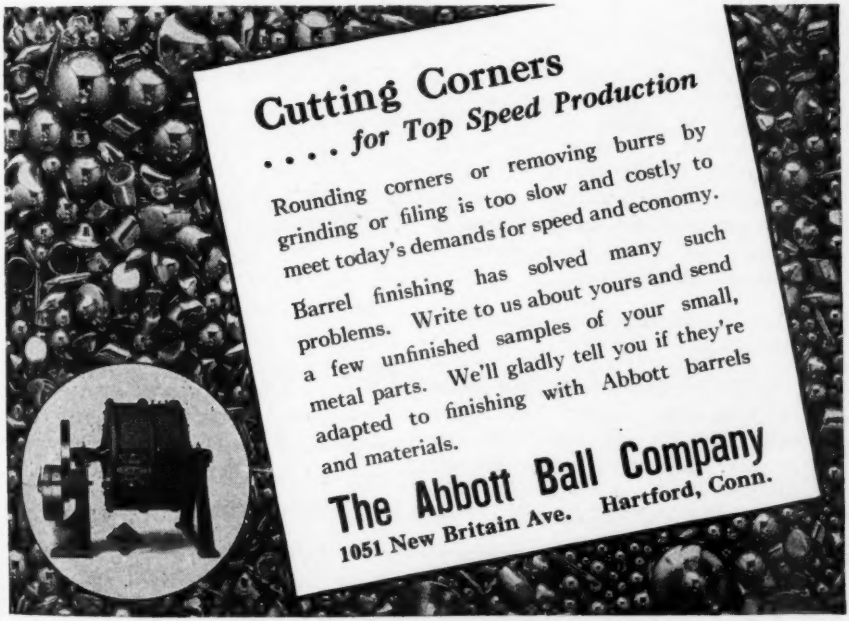
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Business and Social News

BRANCH NEWS

Educational Activities

AMERICAN ELECTROPLATERS' SOCIETY

Newark Branch held a meeting on Friday evening, July 17, 1942 at the Hotel Robert Treat in Newark, N. J. The meeting was called to order at 8:30 P. M. with President William Bruhns presiding. Other officers present were: Robert R. Sizelove, 1st Vice-Pres.; George Wagner, Sec'y-Treas.; John DeVries, Serg-at-Arms; Horace H. Smith, John B. Kotches and Paul A. Oldam, Board of Managers.

The minutes of the previous meeting were read and approved.

A communication from Walter R. Meyer of *Metal Finishing* was read and placed on file.

Application for Edward J. Novak of the Western Electric Co. was voted to take the regular course.

Charles H. Muller, Vernon G. Frey and Herbert J. Mueller were elected to Active Membership; Frederick J. Kirkman, Ellwood I. Neuer, Harvery K. Hunt, William J. Jancik, Harold L. Cobb, Eugene Duchin were elected to Associate Membership.

John E. Yarmack was granted a resignation.

Mr. Horace Smith announced that a committee had decided that there would be no picnic held by the Branch this year. Instead the Newark Branch Members would join the Hillside Elks on their picnic on August 16th

Mr. Paul A. Oldam, acting Librarian, conducted an informal Question Box at which many problems on Zinc, Cadmium and Gold were discussed.

27 members attended this meeting which adjourned at 11 P. M.

GEORGE WAGNER, *Secy.*

Chicago Branch held its regular monthly meeting at the Atlantic Hotel on Friday, August 14, 1942.

President F. K. Savage presided and all other officers were present.

The application of Mr. H. F. Anderson read and a committee appointed on same.

Mr. R. W. Littlejohn and Mr. C. E. Long were elected to active membership, Mr. W. Lockerbie was reinstated to active membership.

The telegram from the Executive committee to announce the death of our National Secretary, Mr. W. J. R. Kennedy read with deep regret and all members of Chicago branch extend to the family of Mr. Kennedy their deepest sympathy.

Mr. D. Greenblatt acted as Serg.-at-arms in the absence of Mr. J. Mintz who is on his vacation.

I am sorry to report the illness of one of our oldest members Mr. Henry Lanz, and Chicago branch members extend their best wishes to Mr. Lanz.

Mr. P. Ritzenthal and Mr. B. Goodsell of Milwaukee branch and Mr. MacIntyre of Cleveland were guests at

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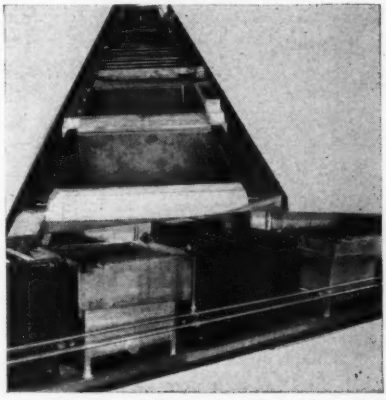

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this meeting and with Mr. F. P. Romanoff they also acted as the board of experts to help answer questions found in the question box.

Mr. Savage appointed the following members as a Banquet Committee to get the details for holding a banquet and educational session and submit them to the members to vote on at our September meeting. Mr. H. R. Smallman, Chairman, C. Clindinin, E. A. Lanz, M. H. Longfield, J. W. Hanlon, H. A. Gilbertson.

Mr. V. Mattcotti, our librarian, introduced the speaker of the evening our own president Mr. F. K. Savage, who presented the very interesting paper by himself and Mr. P. Pfefferle. "Progress Report of the Study of Anode and Cathode Phenomena as Shown by color Photography." The pictures and papers were very instructive and interesting, and the C. G. Conn Ltd. and both members received a vote of thanks from Chicago branch, and we hope to see more of these pictures when Mr. Savage finds time to continue this research.

Mr. J. M. Cosgrove of the War Production Board presented an interesting paper on "Some Phases of Interest Regarding the Equipment and Chemical Rulings Affecting the Electroplating Industry."

The sound motion picture, the final of the nickel series proved to be very interesting and instructive.

Mr. Mattacotti found the following questions in the question box.

Chicago Branch

1. *How thick a deposit is necessary in copper plating to act as a stop off for carbonizing up to 50 thousandths?*

Ans. 5 to 7/10/1000.

2. *What is the effect of lead in a cadmium and zinc solution and how can it be removed?*

Ans. Usually a dark deposit and it can be removed by stirring in zinc dust about 1 lb. to 100 gal. then filter, or with a sulphide, and use a cadmium spongee and filter, for a cadmium solution.

3. *What causes pitting in a bright cadmium solution. Organic brightner, clean solution, bagged anodes, room temp.*, pH 13, 10-20 *amp.*, 2 *Volts?*

Ans. There are 4 types of pitting in a cadmium solution, the efficiency may be low if so caustic should be added to bring it up to 2 or 3 oz. per gal. there may be metallic impurities, or there may be organic impurities due to the type of brightner, use the cadmium spongee, clean and filter.

4. *How many usable electrodeposits are obtained at the anode, what are some?*

Ans. There are several, one of the new ones is a lead black by the Dupont Co., this is done by making the work anodic, and plated about 5 minutes at 10 to 15 amps., it gives a hard, lustre black and stands 15 to 25 hours salt spray test on steel, this can also be used on nickel plated parts.

There were 85 members present at this meeting and the meeting adjourned at 10:45 P.M.

J. W. HANLON, *Secy.*

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The Abstract Section

GEORGE WAGNER, *Chairman, Program and Educational Committee*

Silver Plating. By N. E. PROMISEL and D. WOOD. *Trans. Electrochem. Soc.* **80** (Preprint 35) (1941). Silver plating is used on eating utensils, decorative metal articles, musical and surgical instruments, chemical engineering equipment, and electric circuit parts. In use for more than 100 years, the cyanide bath is superior to other types, a number of which are listed. The functions of the several constituents of the bath are discussed, and curves are given for the effects of various factors on the cathode polarization of sodium and potassium cyanide baths and the nitrate-cyanide bath. Potassium cyanide is generally preferred to sodium cyanide because it permits higher current densities and faster plating without "burned" deposits, and because the potassium carbonate content may be safely permitted to reach 15 oz./gal., while sodium carbonate should be held below 6 oz./gal. on account of adverse solubility and cathode polarization effects. Potassium salts also afford better conductivity and give bright deposits more readily; the only advantage of sodium salts is lower cost, although good results may be obtained with them. Under plant conditions, for semi-bright deposits, additions of potassium carbonate, potassium sulfate, or potassium nitrate were beneficial; potassium chloride, sodium carbonate, or potassium or sodium hydroxides gave fair results; but additions of sodium chloride or nitrate were unsatisfactory. Borate and chloride ions give harder deposits. The effect of these ions is associated with the brightener. The only brightener in commercial use is carbon disulfide, shaken first with a portion of the bath. Although deposits which are nearly mirror-bright may be produced, generally only enough carbon disulfide is added to give semi-bright plates, which are finished almost as readily. On an irregular cathode, there may be many degrees of brightness, and "It may be said that successful silver plating is largely a matter of arranging other factors to provide a suitable condition at the cathode for the most uniform effect of the brightener over the entire surface."

The following compositions are recommended:

	Potassium Cyanide bath	**Sodium Cyanide bath**
Silver	3-4 troy oz./gal.	3-4 troy oz./gal.
Free cyanide	4-6 oz./gal.	4-5 oz./gal.
Carbonate	4-12 oz./gal.	5-6 oz./gal.
Carbon disulfide	As needed, up to 0.0001 fl. oz./gal.	As needed, up to 0.0001 fl. oz./gal.

More than 5 oz./gal. free cyanide is usually required for satisfactory anode corrosion. Because the sodium carbonate bath must be kept low in carbonate, its conductivity and throwing power are limited. Generally a preliminary coat is applied in a "strike" bath:

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	For metals other than steel	First strike for steel
Silver	0.4-0.6 troy oz./gal.	0.1-0.2 troy oz./gal.
Free sodium cyanide	2-3 oz./gal.	8-20 oz./gal.
Sodium carbonate	1-4 oz./gal.	

The following plating bath is coming into use today:

Silver	2-2.3 troy oz./gal.
Free sodium cyanide	2-3 av. oz./gal.
Sodium carbonate	max. 3 av. oz./gal.
Potassium nitrate	15-20 av. oz./gal.

The nitrate assists in anode corrosion and hence permits lower free cyanide and additional brightness of deposit. Strike baths are operated at room temperature, usually with agitation; the current density may be 25 amp./sq. ft. for 5-15 sec., and if a longer strike is desired, the density is dropped to 10-15 amp./sq. ft., or even lower, if no further silver plating is to be done. Plating baths operate at 5-10 amp./sq. ft., at 80°F. pH control is not advantageous. Anode and cathode efficiencies are essentially 100%. The baths have good throwing power, but poor covering power, for reasons outlined in connection with the cathode polarization; this is counteracted by using the strike solutions to cover areas of "counter-potential." Periodic filtration is used to prevent rough deposits, but also removes the brightener. Impurities are generally not troublesome; sodium carbonate and ferrocyanide may be removed by cooling. Full instructions for analysis are given. Bath agitation or stirring is desirable for limiting stratification of the solution. Anodes must be very pure, and are generally rolled silver strip. Even 0.05% of certain impurities (lead, iron, bismuth, manganese, tellurium, selenium, sulfur, antimony) may cause the troublesome "black anodes," and the grain size also has an influence. The anode current density rarely exceeds 10 amp./sq. ft. In preparing the basis metal, three factors should be considered: (1) deposition by immersion; (2) the difficulty of covering solder and other "counterpotential" areas; (3) the tendency of the deposit to reproduce the surface structure of the basis metal. Often the use of one or more "strikes" is sufficient. Sometimes a mercury dip before striking is required; however, undercoats of tin or nickel are preferred. Specifications are given for coating weights on flatware, cutlery, hollow ware; tests are usually made by stripping, although the Mesle chord method and other tests may be used. A good deposit is one which can be readily buffed. The paper abounds in much practical and theoretical discussion.

ERNEST H. LYONS, JR.

Change of Structure of Electrodeposited Metals as a Function of the Rate of Their Passivification. I. Change of the number of Crystals Formed in the Electrodeposition of Silver. By A. T. VAGRAMYAN. *J. Phys. Chem.* (U.S.S.R.) **14,** 1132-8 (1940); *Chemical Abstracts* **35,** 4228 (1941). In the electrodeposition of silver from nitrate solutions, with additions of chloroform, dextrin, or benzoic acid, the number of crystal nuclei formed depends on the state of the active surface and is a measure of its passivity. The number of nuclei formed increases with increasing potential and c.d.

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The Electrolysis of Solutions of Cuprous Salts Containing Carbon Monoxide. By HEINZ MOELLER and KURT LESCHEWSKI. *Z. anorg. allgem. Chem.* **244,** 329-34 (1940); *Chemical Abstracts* **35,** 4288 (1941). The electrolysis of ammoniacal solutions of cuprous salts containing carbon monoxide yielded copper plates, and carbon monoxide was given off at both the anode and cathode, which were of platinum. Nitrogen and hydrogen were also evolved, and sometimes chlorine. ERNEST H. LYONS, JR.

Insoluble Anodes in the Electrolysis of Zinc Sulfate containing Chlorine in Solution. By J. L. BRAY and F. R. MORRAL. *Trans. Electrochemical Society* **80** (preprint 17) (1941). In electrogalvanizing with insoluble anodes, lead containing 3.5% thallium, 0.05% calcium, and 0.03% tellurium was found to be less soluble than other alloys, when the solution contained as much as 3.6 g./1. chloride ion. Thallium is known to make lead resistant to brine, and to reduce the lead in the zinc deposit; tellurium refines the lead grains and makes them less soluble under anodic current; calcium reduces the coltage loss. ERNEST H. LYONS, JR.

Decorative Chromium-Plating of Sandblasted Iron Articles on a Copper Undercoat. By YA L. VERTSMAN. *J. Applied Chem.* (U.S.S.R.) **14,** 507-16 (1941). *Chem. Abstracts* **36,** 3102 (1942). Chromium plated iron articles are entirely satisfactory where Cr-plated brass has been used. For corrosion resistance an undercoat of copper or nickel is required; copper was more economical. The plating was done as follows: After sandblasting, the articles were electrocleaned in a hot alkaline bath, 2 min. as cathode and 15 sec. as anode. They were then dipped in muriatic acid and brushed to remove imbedded sand. Next they were etched in 2:1 sulfiurc-nitric acids, for 6-8 secs., rinsed, dipped in 300 g./1. CrO_3 plus 3 g./1. H_2SO_4 for 4-5 sec., washed and dipped in concd. HCl for 1 sec. They were then copper-plated in an acid bath. Nickel undercoats less than .0009″ thick show immersion deposits of copper on dipping into an acid copper solution. Nickel layers over 0.001″ thick show copper spots after a 2 min. dip. The thickness of nickel assuring a perfect bond with a subsequent acid copper deposit is about 0.00127″. A copper layer less than .00025″ thick from a cyanide bath shows copper deposits by immersion and peeling on dipping 1 sec. in $CuSO_4$. The cyanide copper deposit must be .0005″ thick to receive an adherent deposit from the acid copper bath. For polished steel bases, these thicknesses may be reduced. After copper plating, the articles were etched in a bath of 1 1. HNO_3 (d. 1.3-1.32), lampblack 10g., NaCl 10g., for 2 sec., washed, then in a bath of 1 1. H_2SO_4 (d 1.8-1.82), 1 1. HNO_3, NaCl 16g., for 1 sec. and rinsed. The cycle was repeated 2 to 3 times to get a bright surface. The Cr-plating bath contained 300 g./1. CrO_3 and 2 g./1. H_2SO_4 at 112-116°F., with 93 to 140 or even 230 amp./sq. ft.; the electrolytic "shock" of 460 amp./sq. ft. was applied twice, for 2 min; after rinsing, the plated articles were soaked 30 min. in 100 g. Na_2CO_3/1. at 176° F., which is a very important step to insure neutralization of the chromic acid. After the soak, the articles were washed in hot distilled water and dried at 400° F. for 25-30 min. ERNEST H. LYONS, JR.

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NEWS ITEM

The manufacturing, sales and service of Rackote plating insulations have been combined as The Rackote Division of Wyandotte Paint Products Company, Wyandotte, Michigan, it has just been announced. The move, which combines and enlarges Rackote's sales and manufacturing facilities, is designed to serve America's war effort more effectively by meeting the greatly increased demand for Rackote Insulations.

Rackote, the company's principal product, is a new type of insulation for plating racks, and is recommended for chrome, cadmium, high speed copper, nickel, tin and zinc, and especially for anodizing and parkerizing. Unlimited quantities are immediately available, company officials state.

In addition to Rackote, the company manufactures Tankote for insulating plating tanks, and a wide variety of plastic plating masks. New literature is being prepared on all these products and is available on request.

NEW HYDRAULIC PUMP

A 6-Plunger, fully enclosed, Horizontal, Hydraulic Pump—an addition to a broad line manufactured by the Charles F. Elmes Engineering Works.

The Pump is modern in appearance and embodies the latest principles of design and construction. All moving parts are pressure lubricated and the Connecting Rods run in a continuous bath of oil. Roller Bearings are used throughout.

Maximum capacity of the pump is 400 Horsepower. Herringbone Gears, running in a continuous bath of Oil, are used for driving the Pump, insuring long Gear life. The compact arrangement of the Pump is a space saver, and it is particularly adaptable for Accumulator systems.

The Pump can be equipped with built-in Bypass Valves or Safety Valves, as may be desired. Complete data covering the features of this Pump will be gladly furnished by the Charles F. Elmes Engineering Works, 230 N. Morgan St., Chicago, Ill.

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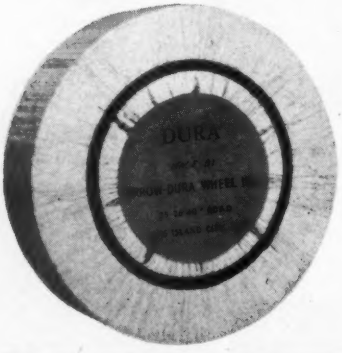

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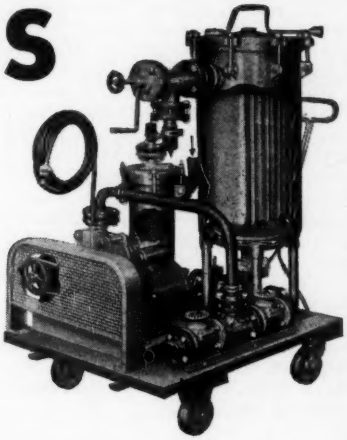

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The "LEAK-PROOF", "CORROSION-PROOF" and non-contaminating construction of Industrial Filters is a vital requisite of Electroplating filters.

SALT SPRAY
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For testing—Electroplated or coated metals at 95 deg. Fah. in accordance with Army, Navy and Aeronautical specifications, as outlined in Bulletin AN-QQ-S-91-5 dated Dec. 1938. Also for controlled temperatures at any degree. Testing Cabinets lined throughout with rubber. Made in 4 sizes.

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These new "TYGON" formulations consist of pure "TYGON", liquified to form a stable, non-adhesive film when dried. "TYGON" TEMPRO-TEC, in crystal clear or transparent colored formulations for ready identification purposes, is applied by brush, dip, spray or roller coating. It air dries within a few minutes at normal room temperatures to form a sturdy, durable, elastic film, unaffected by oil, grease, gasoline or corrosive atmospheric fumes or condensates. "TYGON" TEMPRO-TEC will not become brittle under sunlight, is unaffected by active oxidizing agents, water, alcohol or brine solutions.

"TYGON" TEMPRO-TEC easily strips free, peeling off as a complete film without danger of injury to the surface beneath.

"TYGON" TEMPRO-TEC provides excellent protection for surfaces of machine parts, tools, bearing surfaces, etc., during handling, shipping, installation; it is likewise an effective tarnish preventative for sterling silver, plated silver, chrome, nickel or gold, copper or other metals, while in storage, transit or on display.

NEW BOOKLET NO. 6

Pennsylvania Salt Manufacturing Company, chemicals, is announcing the issue of Booklet No. 6 on Penchlor Acid-Proof Cement, available to interested companies on request.

The new booklet presents recent data together with photographs and charts showing installations and methods of installation. The "how to use" section has been brought up to date, while chemical, physical and electrical properties are presented in complete detail.

DEGREASING SOLVENT

Two new illustrated leaflets describing the high stability of Perm-A-Clor degreasing solvent under adverse operating conditions, are now being issued by the Detroit Rex Products Company, 13005 Hillview Avenue, Detroit, Michigan. This chlorinated solvent is non-flammable and is used for cleaning all kinds of metal parts.

NEWS RELEASE

Chester W. Smith has joined the staff of the **Detroit Rex Products Company,** 13005 Hillview Avenue, Detroit, Michigan, as Research Chemist in the Alkali Division.

Mr. Smith has been a specialist in the field of electrochemistry as applied to electroplating for the past eight years. He was formerly affiliated with the J. C. Miller Company as chief chemist working on research and development of materials for the field of electroplating.

He was 1942 National Convention Chairman for the American Electroplaters' Society, as well as vice-president and librarian of the A.E.S. Grand Rapids branch. He is also a member of the American Chemical Society.

METALWASH MACHINERY COMPANY OPENS NEW PLANT

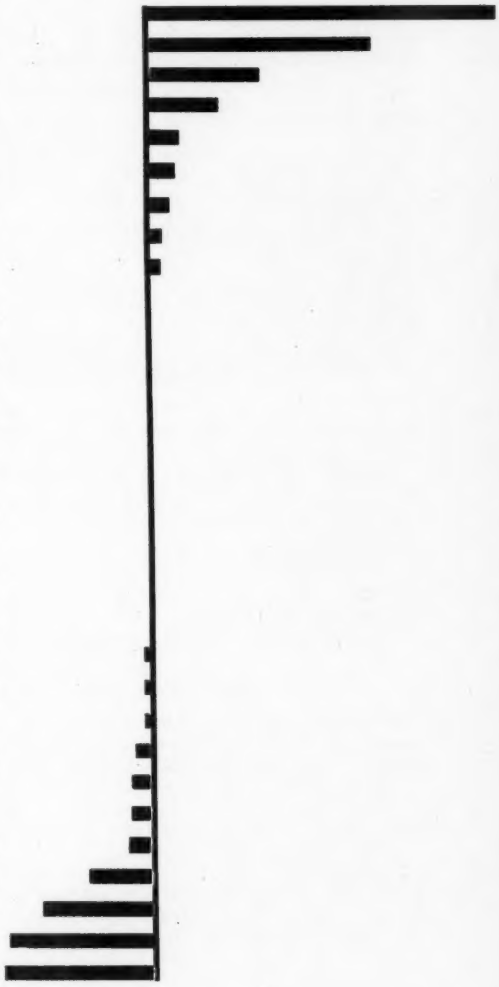
About September first Metalwash Machinery Company will move their main office to their new plant located at 149-157 Shaw Avenue, Irvington, N. J.

The new plant will be known as plant No 1 and the old plant at 27-29 Haynes Avenue Newark, N. J. will be known as plant No. 2.

The two plants are well equipped to provide for increased output of special machines which are used extensively in the output of war materials at government specifications.

MEMBERSHIP CAMPAIGN REPORT

BRANCH	May 1, 1942	Change in Membership	Percent Change
Cleveland	81	+16	+19.8
Indianapolis	48	+6	+12.5
Syracuse	31	+2	+ 6.5
Pittsburgh	52	+2	+ 3.8
Buffalo	55	+1	+ 1.8
Chicago	258	+4	+ 1.6
Balt.-Washington	82	+1	+ 1.2
Philadelphia	142	+1	+ .7
Newark	156	+1	+ .6
Binghamton	16	0	0
Boston	118	0	0
Detroit	277	0	0
Lancaster	44	0	0
New Haven	105	0	0
Prov.-Attleboro	49	0	0
Rochester	80	0	0
San Francisco	46	0	0
St. Louis	82	0	0
Toledo	46	0	0
Toronto	87	0	0
Waterbury	97	0	0
Milwaukee	97	—3	— .3
New York	139	—4½	— .3
Springfield	72	—2	— .3
Los Angeles	128	—1	— .8
Dayton	99	—1	— 1.
Grand Rapids	87	—1	— 1.1
Bridgeport	80	—1	— 1.3
Montreal	44	—1½	— 3.4
Hartford	67	—4	— 6 0
Anderson	38	—3	— 7.9
Cincinnati	49	—4	— 8.2



NOTE: Honorary members are included with each Branch.

MEMBERSHIP — May 1st, 1942 = 2842
MEMBERSHIP — Sept. 1st, 1942 = 2850
GAIN IN MEMBERSHIP 8
GAIN = .28%

DU PONT ANNOUNCES NEW MANUAL ENTITLED "MOLTEN SALT BATHS"

A new 72 page illustrated manual published by the Electrochemicals Department of Du Pont on the subject of "Molten Salt Baths" is ready for release.

Copies of the manual will be sent to executives and engineers who request it on their business letterheads. Requests should be sent to the Electrochemical Department of the Du Pont Company, Wilmington, Delaware.

MEN WANTED FOR POSITIONS PAYING FROM $2,600 to $6,500 A YEAR

United States Civil Service Commission is seeking well qualified persons with experience in non-ferrous metals and their products. Appointees should have a college education with a major in economics, and responsible experience or research work in the manufacture or distribution of non-ferrous metals and their products.

Those interested and able to qualify should contact Mr. J. S. Hathcock, Examiner in Charge Economics and Statistics Unit, U. S. Civil Service Commission at Washington, D. C.

COURSES IN ELECTROPLATING

The Institute of Electrochemistry and Metallurgy, 59-61 East Fourth Street, New York City, will offer specialized courses in the field of electroplating and metallurgy during 1942-43.

Registration for fall course will be held from September 21st to 25th. For the spring term from February 1st to 5th.

The following courses will be offered:

Fall Courses:

Electroplating	1
Metallurgy	1
Research	1
Industrial Microscopy	1A

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NEW WIRE AND TAMPICO BRUSHES

The Hanson-Van Winkle-Munning Co., Matawan, N. J., have developed a new line of wire and tampico brushes, for cleaning, finishing and polishing metals. Wire sections made in sizes 6" up to 18" inclusive.

These products have been given the trade name STAPLBOND. Each section is approximately 3/8" thick, a complete brush in itself but any desired face can be obtained by adding sections directly to the shaft. Use of hub or adapters not required.

STAPLBOND sections are noted for sturdiness. Wires of each section stand out stiffly and produce uniformly sharp scratching surface. Wears down evenly. Manufacturer claims there is a continuous sweeping action not found in other type brushes.

A NEW BOOKLET

The Du-Lite Chemical Corp. of 3 River Road, Middletown, Conn. have just issued a booklet about the Du-Lite Process of Black Oxide finishing of steel parts and products. Sent free on request.

It describes the development, operation and advantages of the Du-Lite process, the equipment used, special cleaners and oils used and developed by the Du-Lite Chemical Corp. and the service rendered by them for the successful operation of the Process.

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MEMBERSHIP REPORT

MAURICE R. CALDWELL, *Chairman, Membership Committee*

To September 1, 1942

APPLICATIONS

Chicago Branch

H. F. Anderson Associate

Newark Branch

Edward John Novak Active

ELECTIONS

Chicago Branch

C. E. Long, 1802 Preston St., Rockford, Ill. Active
R. W. Littlejohn, 516 14th St., S.E., Cedar Rapids, Iowa Active

RESIGNATIONS

H. B. Wilcox, Chicago Branch

REINSTATEMENTS

W. Lockerbie Chicago Branch

SUSPENSIONS

C. C. Johnson Chicago Branch

DEATH

Toronto Branch

Mr. James Brady Associate

James Brady

Mr. James Brady, associate member of Toronto Branch was drowned at Port Dalhousie, Ontario while swimming August 19th. Mr. Brady was superintendent of the Toronto Cadmium Plating Co.

The members of Toronto Branch wish to express their sorrow in the loss of one of our good members. Our deepest sympathy is extended to the widow and family of the deceased.

JAMES S. CAIRNS.

We would like to express our sincere appreciation for the beautiful floral pieces and the many kind expressions of sympathy sent by the members of the A.E.S. at the death of the Executive Secretary.

Mrs. W. J. R. Kennedy and Family.